

Chris Smith of Swales at work on
Probe Head of BB1d [(c) 2000 JPL]

The Mars Microbeam Raman Spectrometer (MMRS):

*From Concept to
Category-1 Proposal*

Probe Head BB1d targeted at calibration
rock sample [(c) 2000 JPL]

Brad Jolliff

Washington University

MEPAG, 4/20/2006

Camera

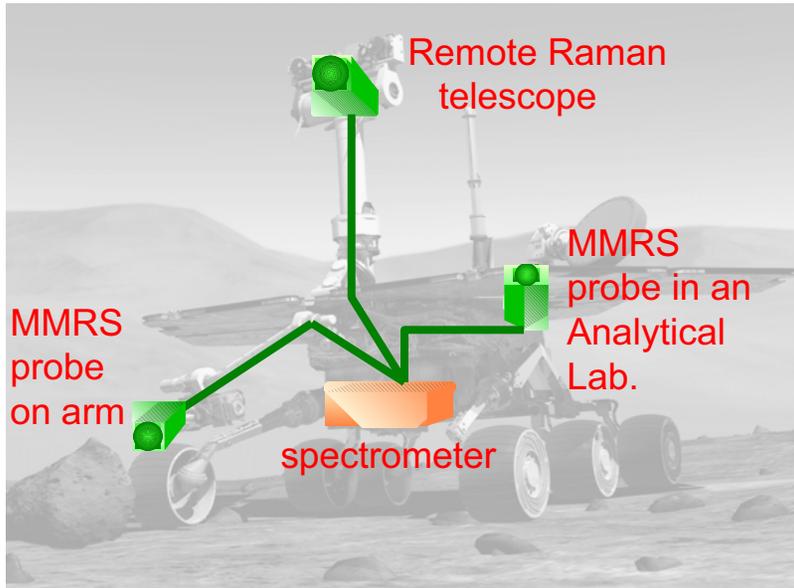
Spectrometer

Probe BB1c

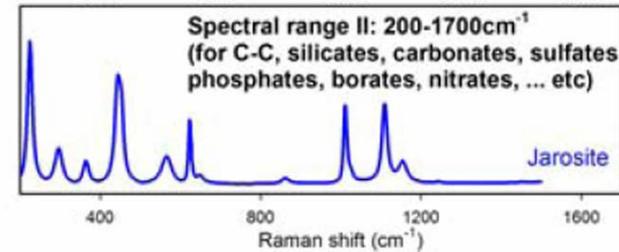
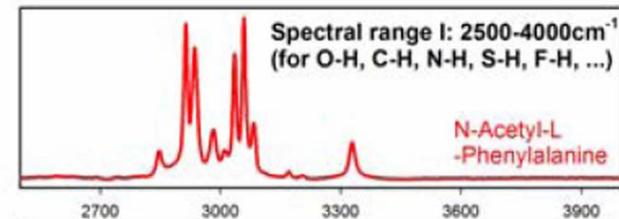
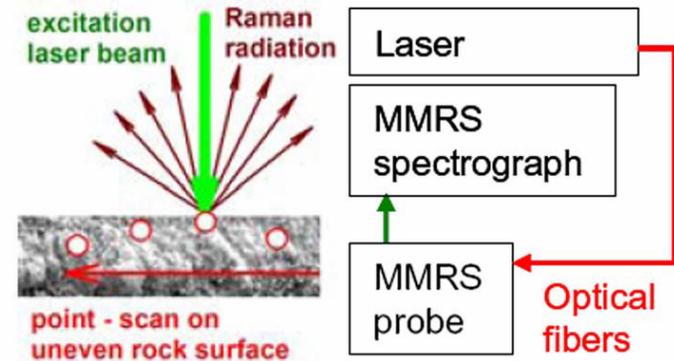
Laser

- **Formulating the Concept**
- **Science Rationale and Applications**
- **Development History**
 - **First Opportunity & Teaming with JPL**
 - **Further Development – Athena '03**
 - **Continued Development – MSL**
- **High Hurdles and Lessons Learned**

Mars Microbeam Raman Spectrometer



How the MMRS Works



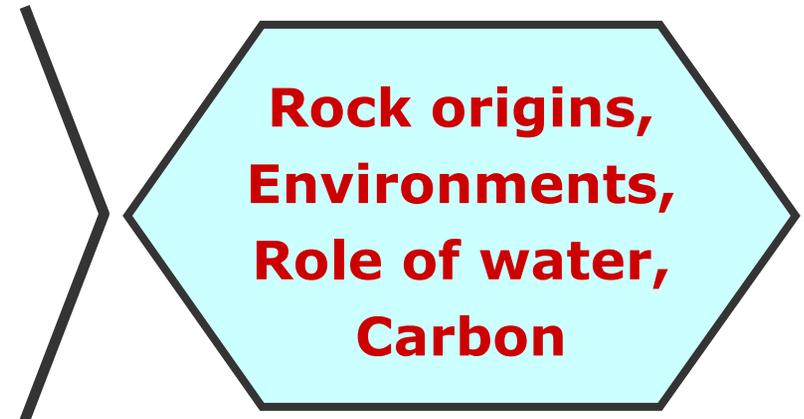
- Laser Raman Spectroscopy is flexible – can be deployed in many ways.
- MMRS tailored for rover-based mobility platform and for Mars fundamental science objectives.

Sharp non-overlapping Raman peaks yield definitive molecular identification

- Hallway chats, Lunar Discovery concepts (early '90s), and a clever Raman Spectroscopist...
- Tests using laboratory instruments on lunar samples
 - **The would-be PI had to be convinced...**
 - Results presented at LPSC & other conferences
- JPL Raman Spectroscopy Workshop, 1997

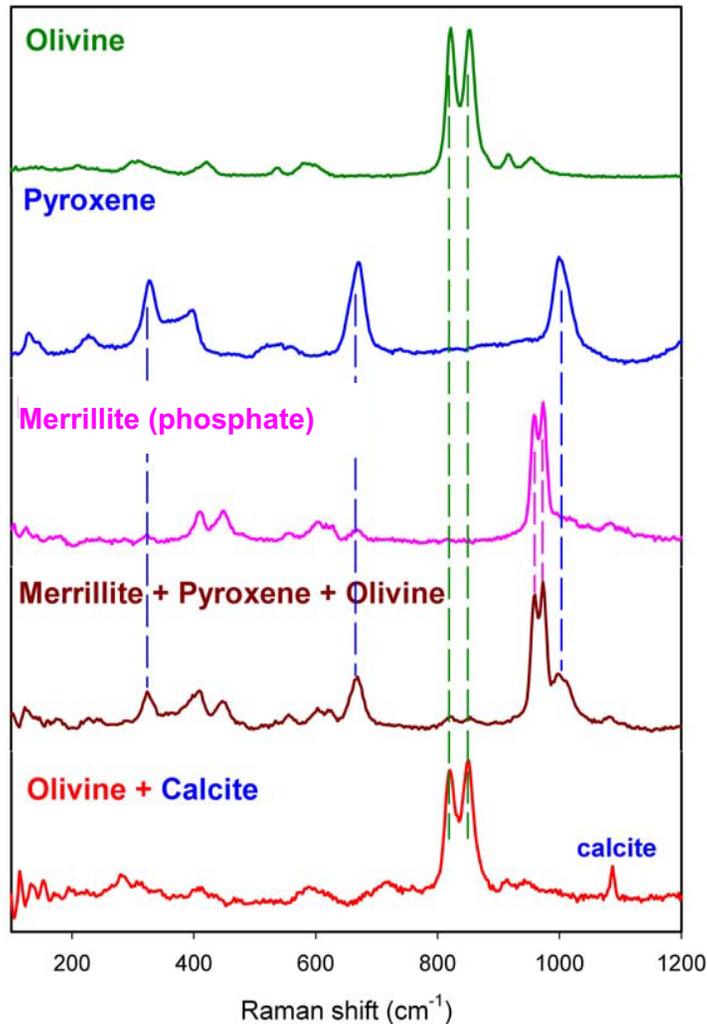
❖ **The MMRS was initiated by science requirements – to determine mineralogy, mineral chemistry, & molecular phase identification, including organics.**

- **Rock-forming mineral identification**
- **Identify minerals in mixtures**
- **Mineral Chemistry**
- **Mineral Modes (proportions)**
 - Including minor/trace phases
- **Alteration**
 - Olivine alteration
 - Phyllosilicate clay alteration
 - hydration
- **Bio-Signatures**

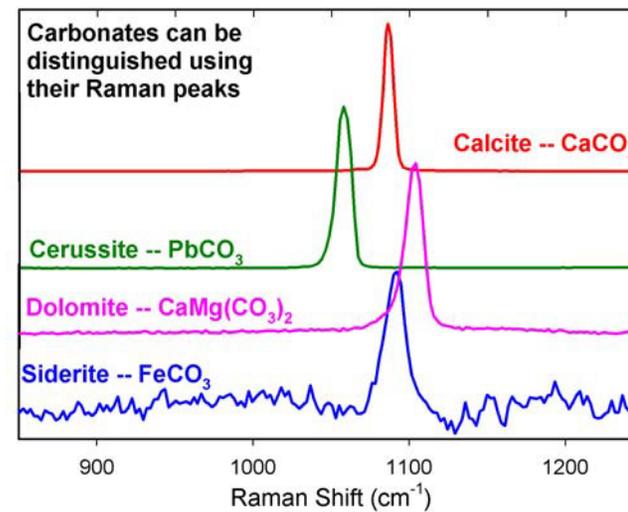


Science is the driving force for development.

Igneous

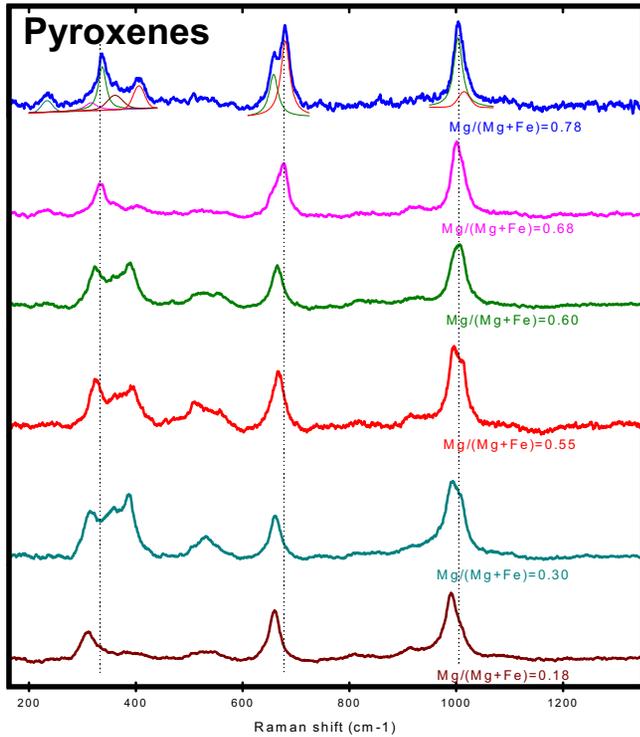


Sedimentary



Mineral mixtures are readily determined because peaks are sharp and non-overlapping.

Mars Microbeam Raman Spectrometer



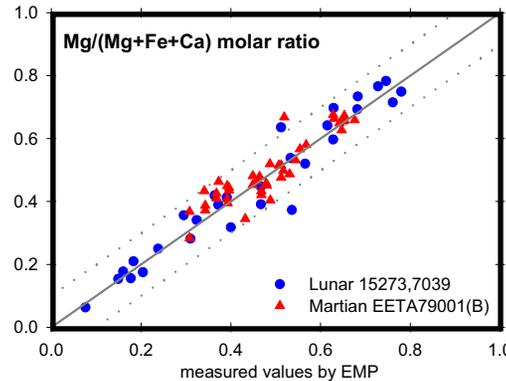
Structure
orthorhombic

monoclinic

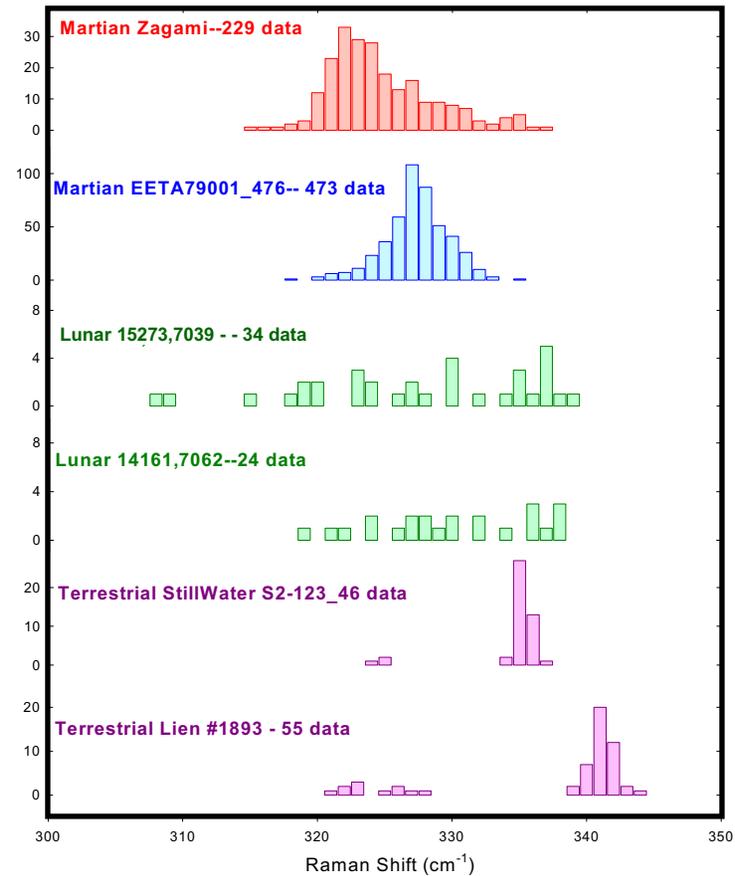
triclinic
(pyroxenoid)

Composition

Mg/(Mg+Fe+Ca)

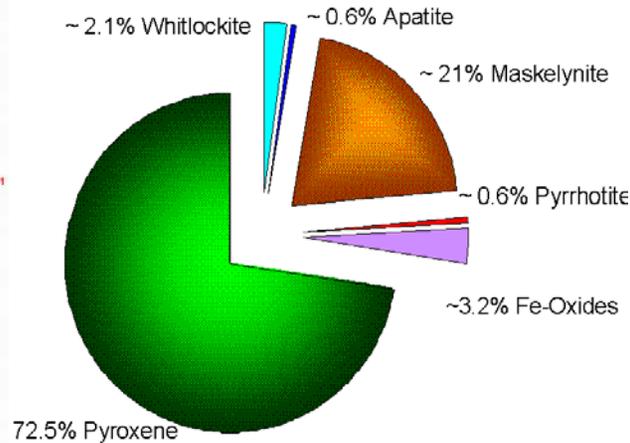


Crystallization History



Distribution reflects cooling history

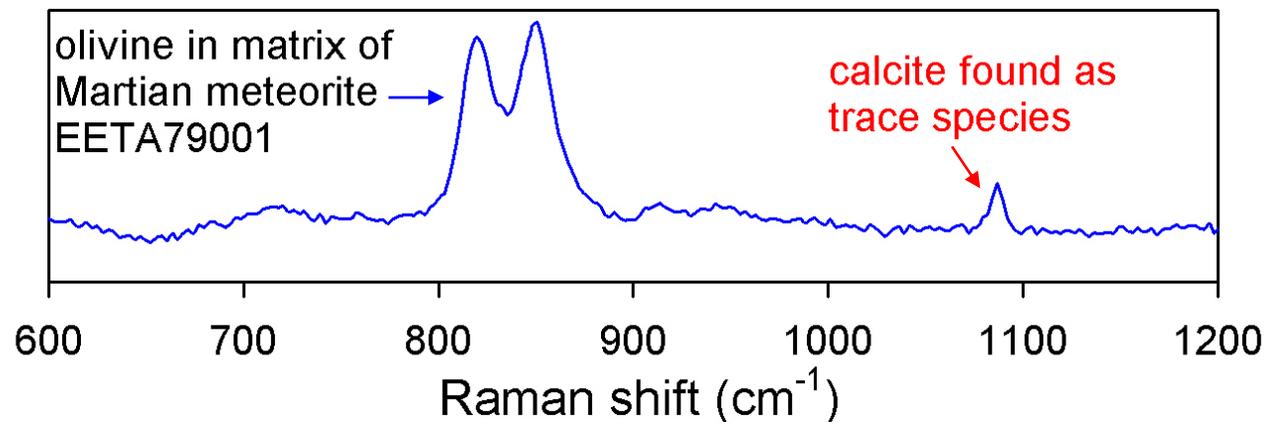
Zagami



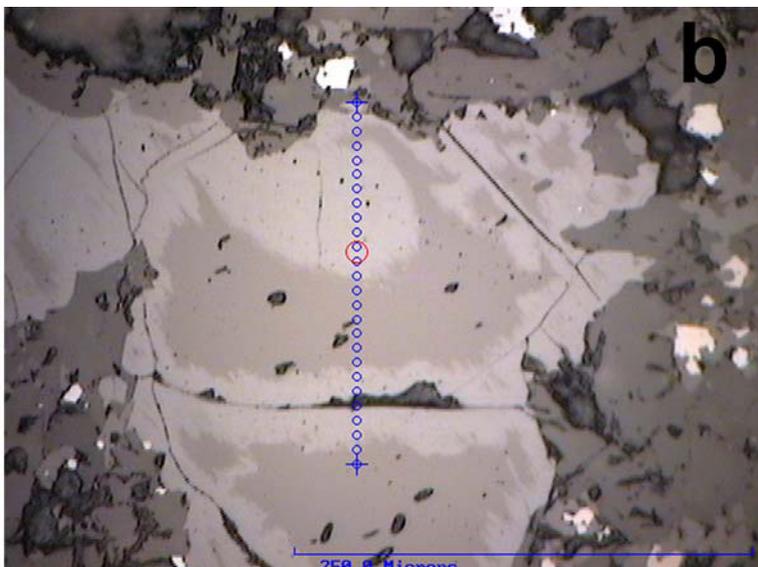
What is the mineral assemblage?

What does it tell us about the rock's origin?

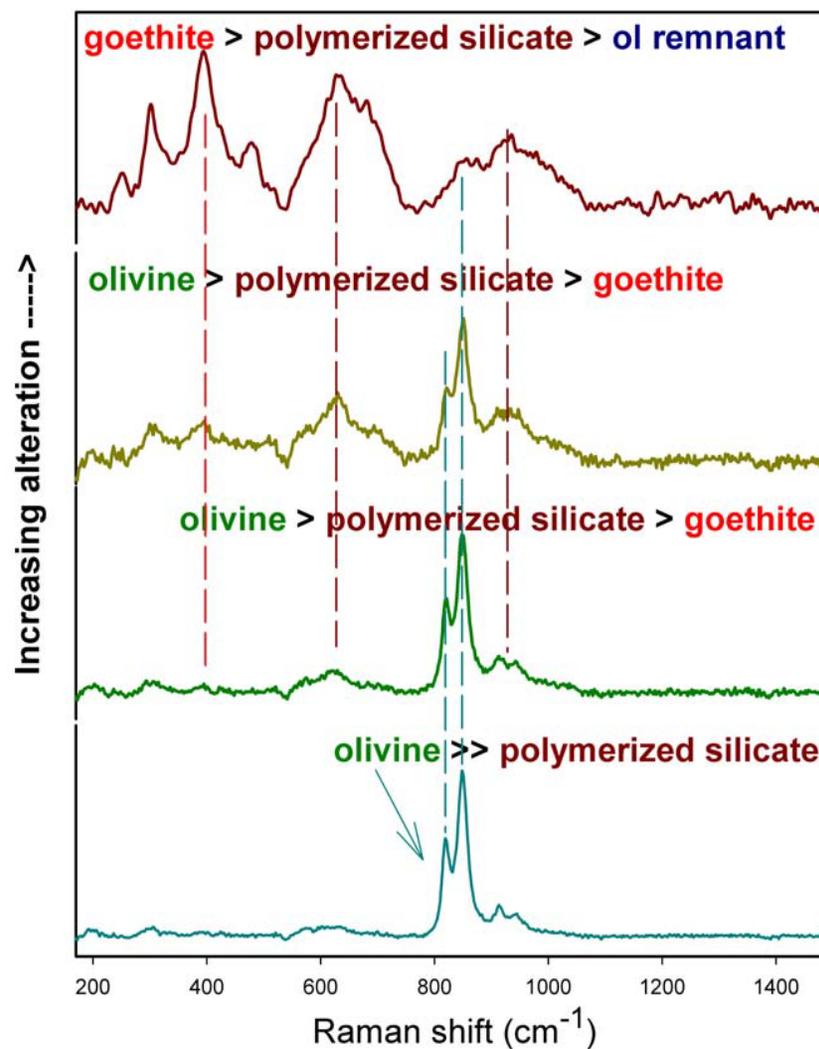
Secondary phases indicate alteration process.

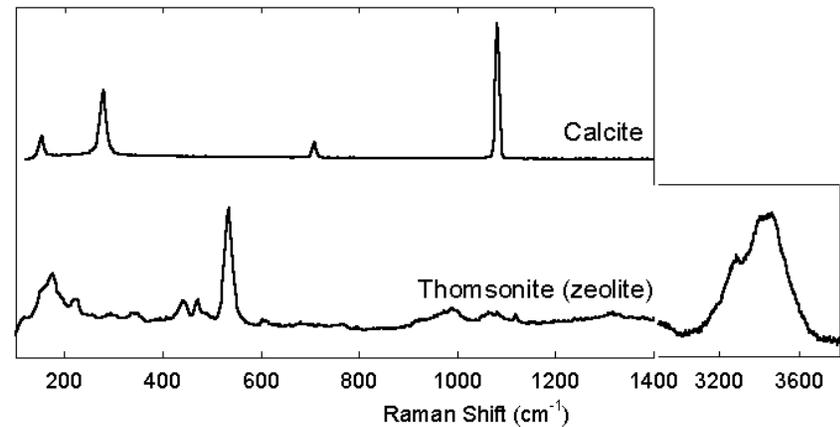
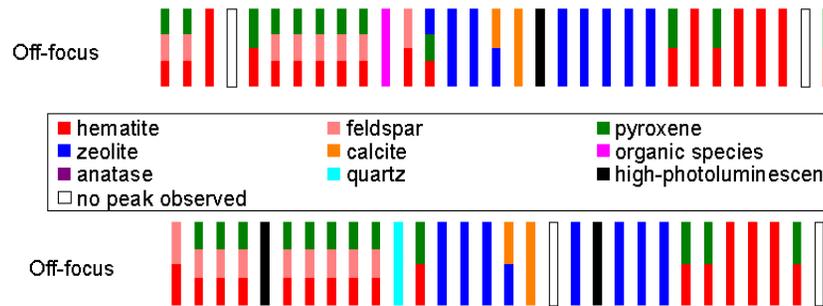
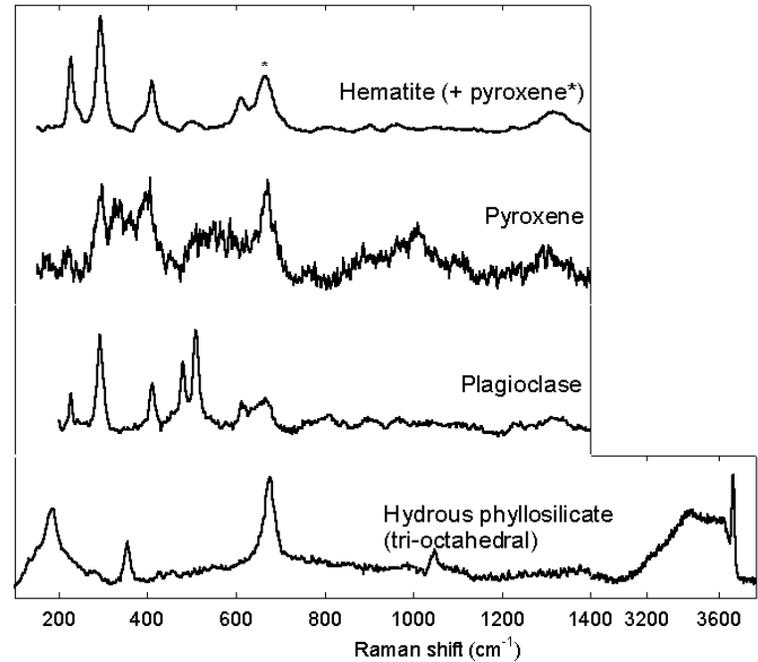
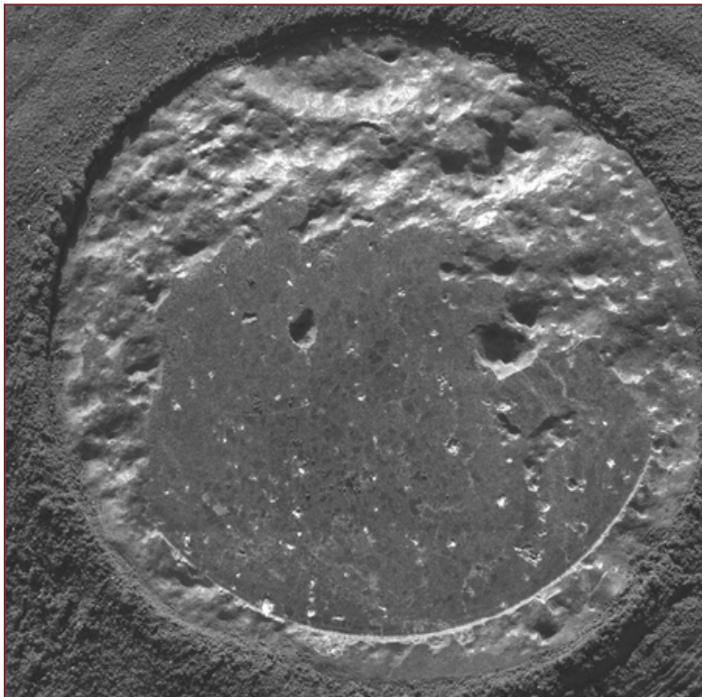


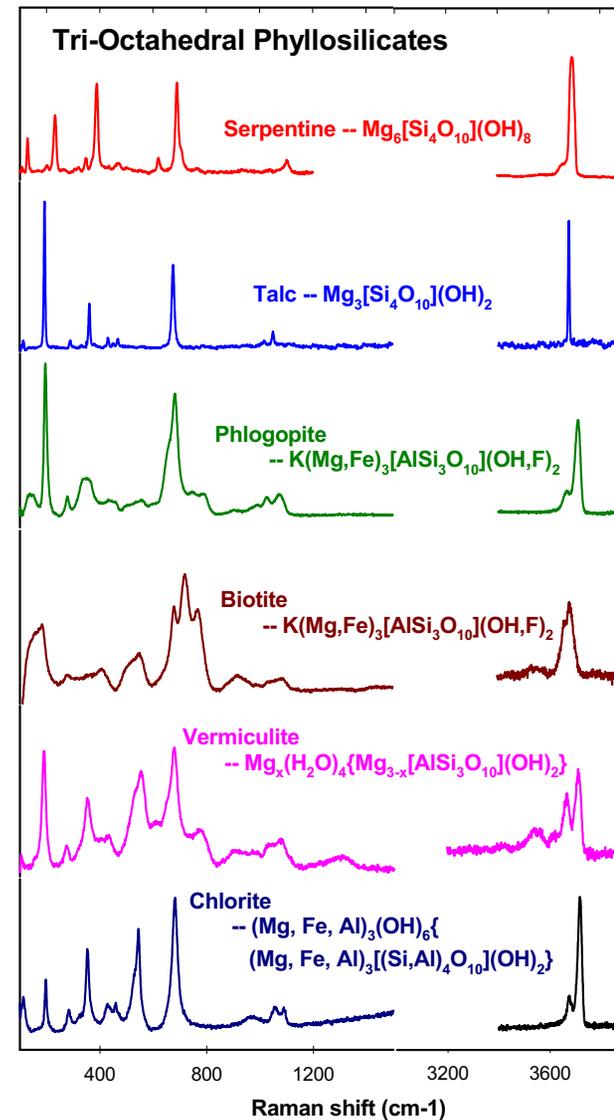
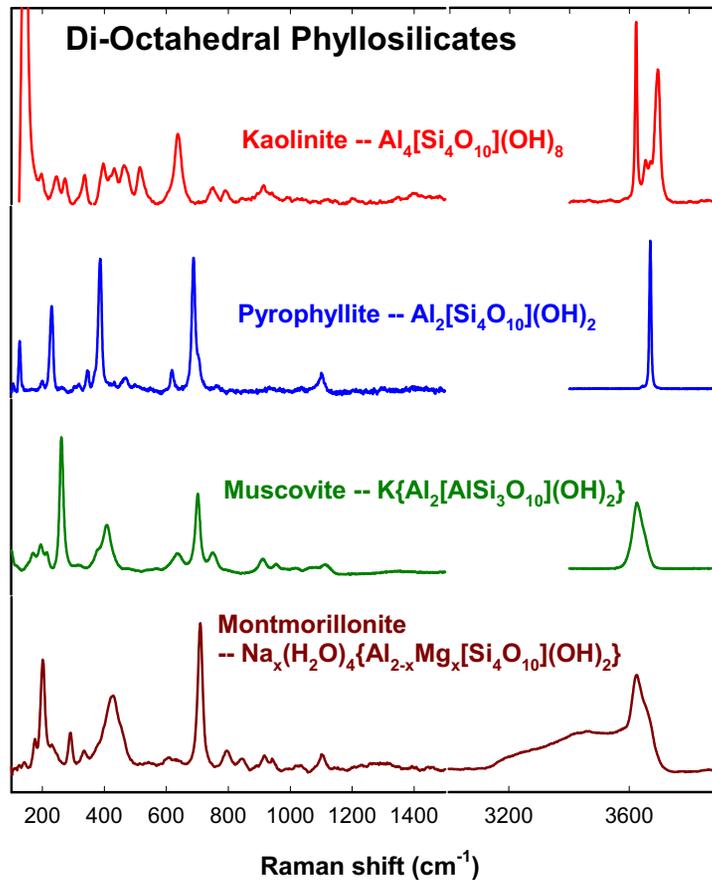
What is the degree of alteration and what was the environment in which it occurred?



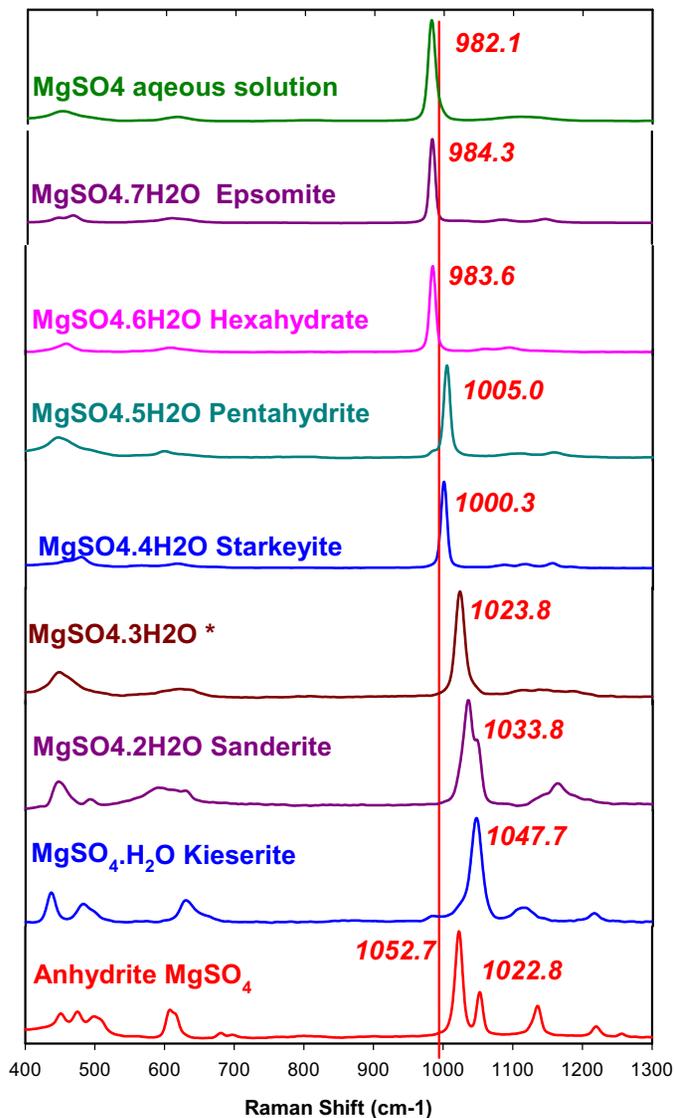
Reflected-light microscopic image of olivine partially altered to iddingsite.



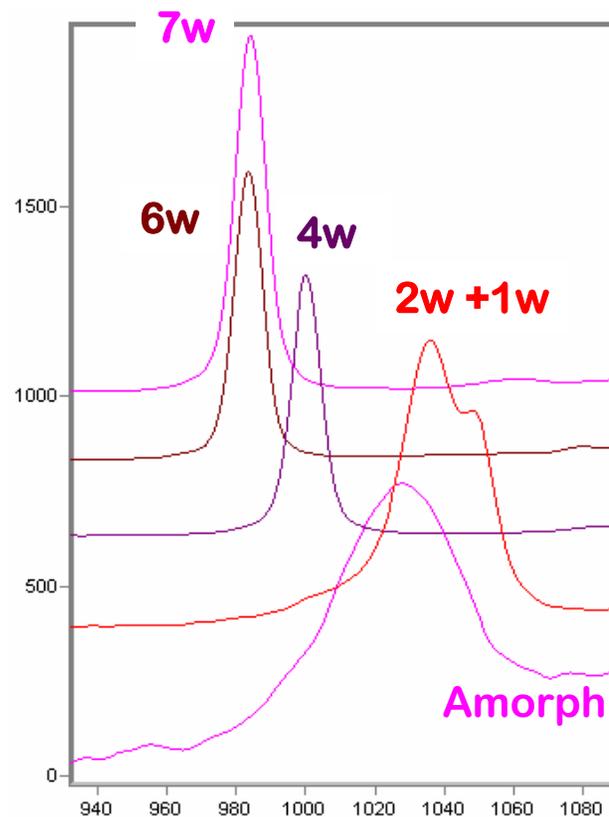




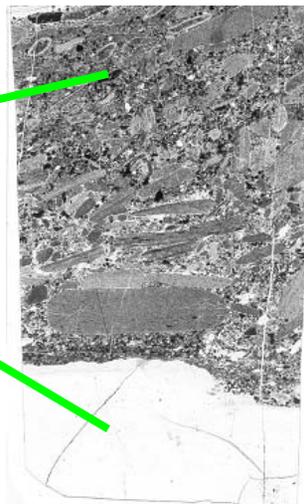
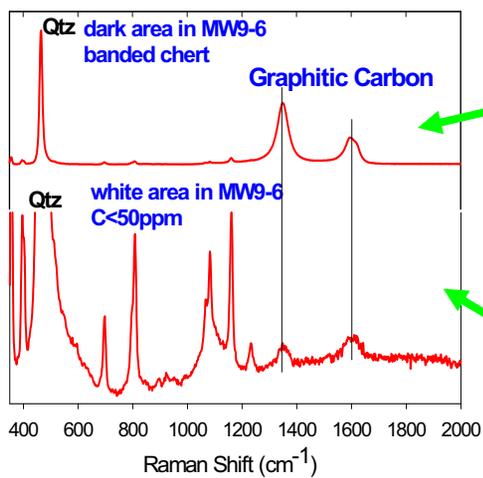
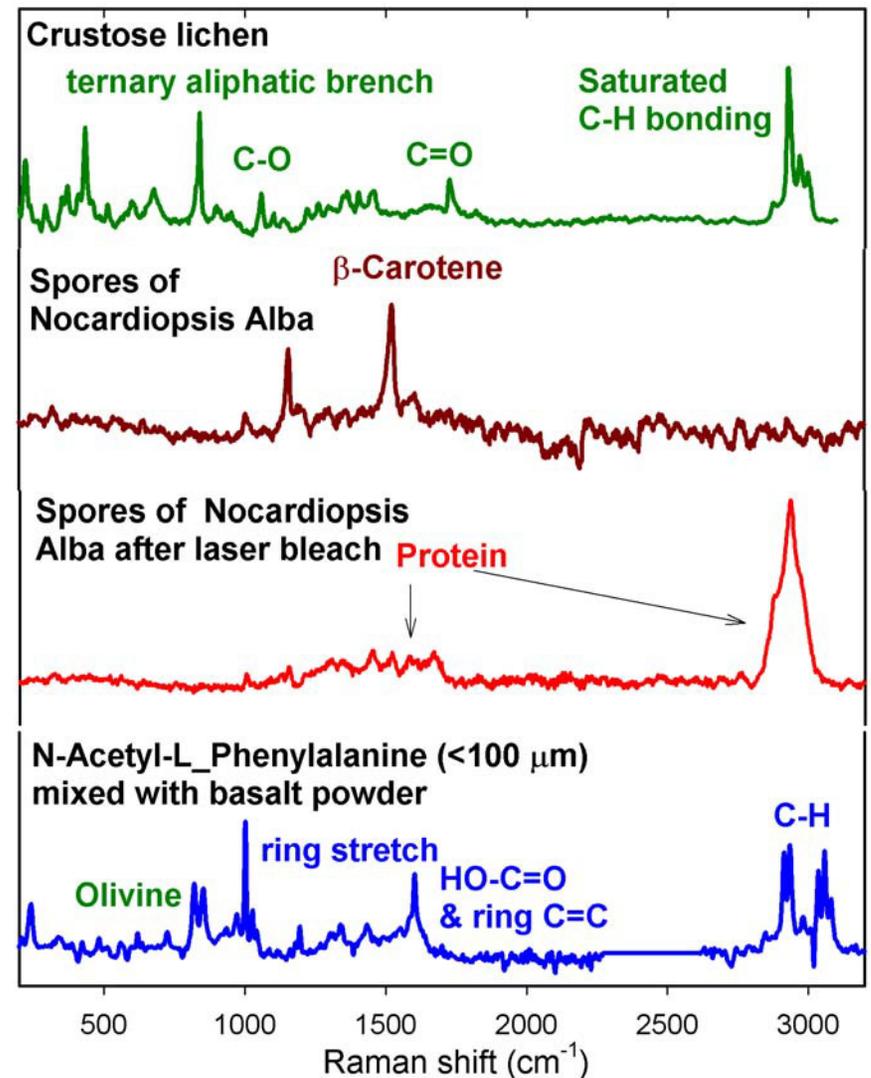
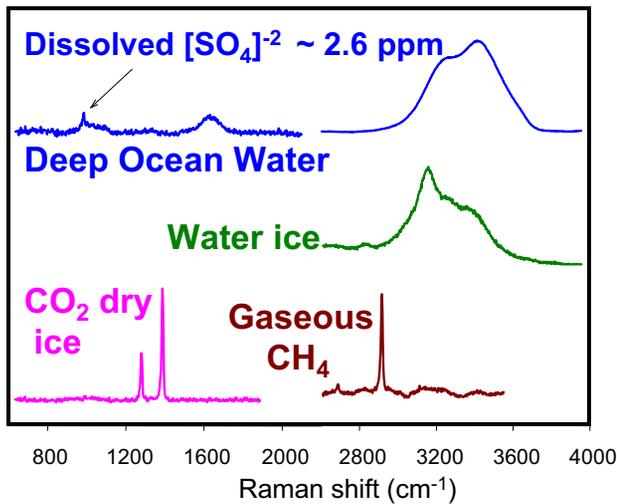
How & where is water sited and what were the conditions of formation?



How much water is held in martian sulfates?

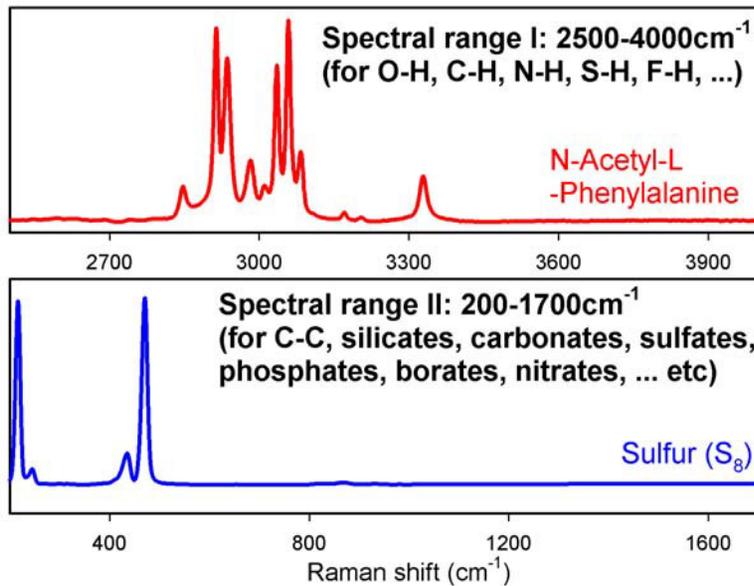


Mg-sulfate phase changes

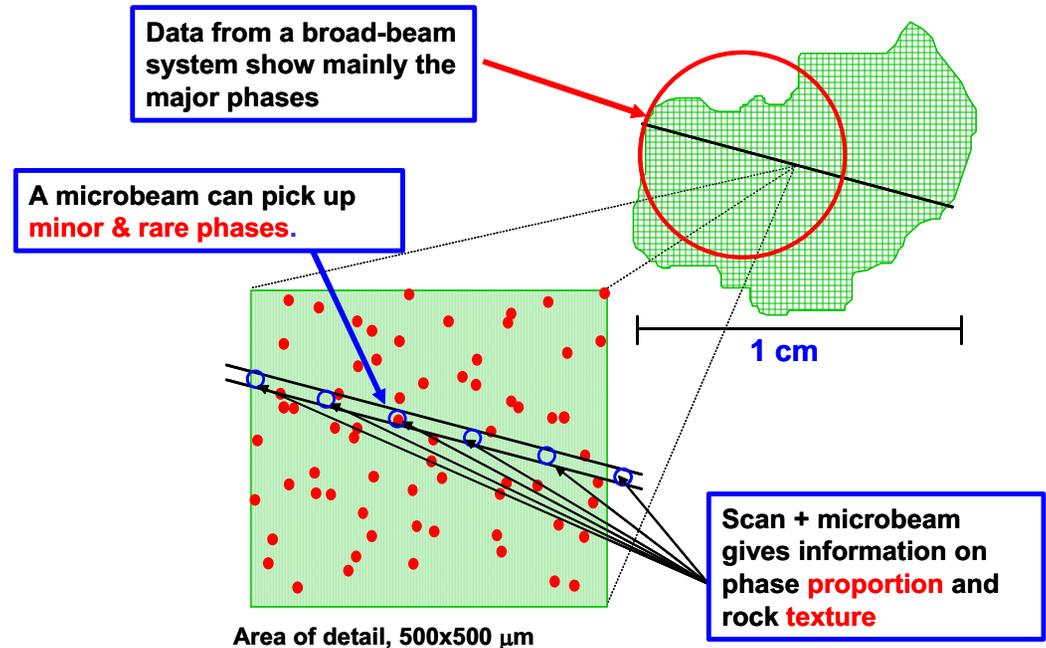


Mars Microbeam Raman Spectrometer

High resolution & wide range



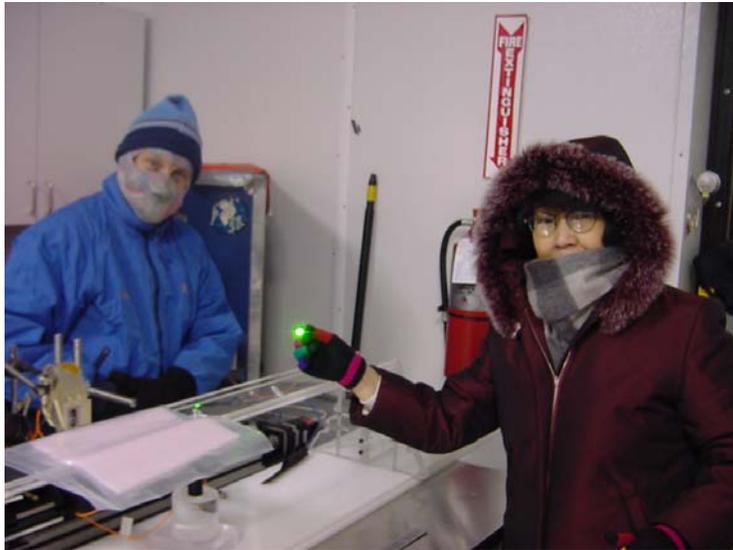
Microbeam & line scan



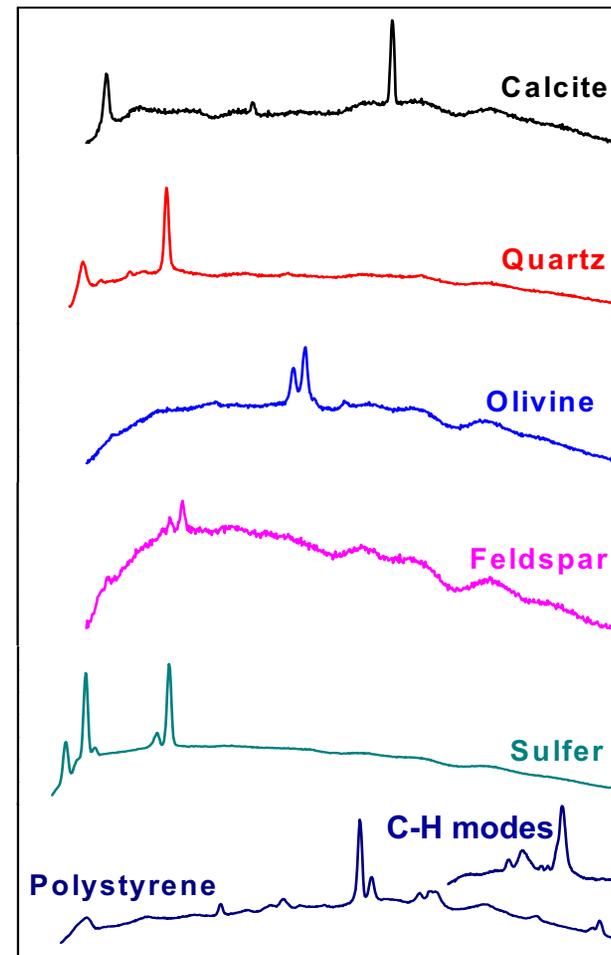
- **PIDDP: 1996-1997 (Washington Univ.)**
- **MSR Athena '01/'03 payload: 1997-2001**
- **Additional PIDDP (WU)**
- **MIDP (JPL)**
- **Institutional funds**
 - JPL internal funds
 - Washington University (L. Haskin)
- **[Science Programs (e.g., MFRP)]**

Dedication of PI and team members has been based on recognition of the scientific importance of this technology, not \$\$.

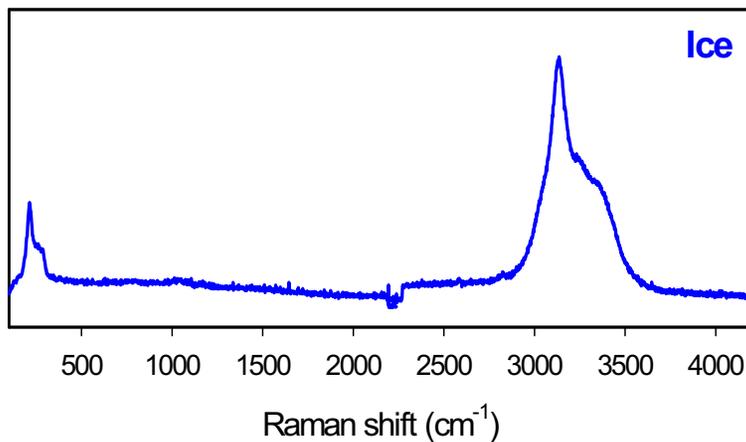
Mars Microbeam Raman Spectrometer



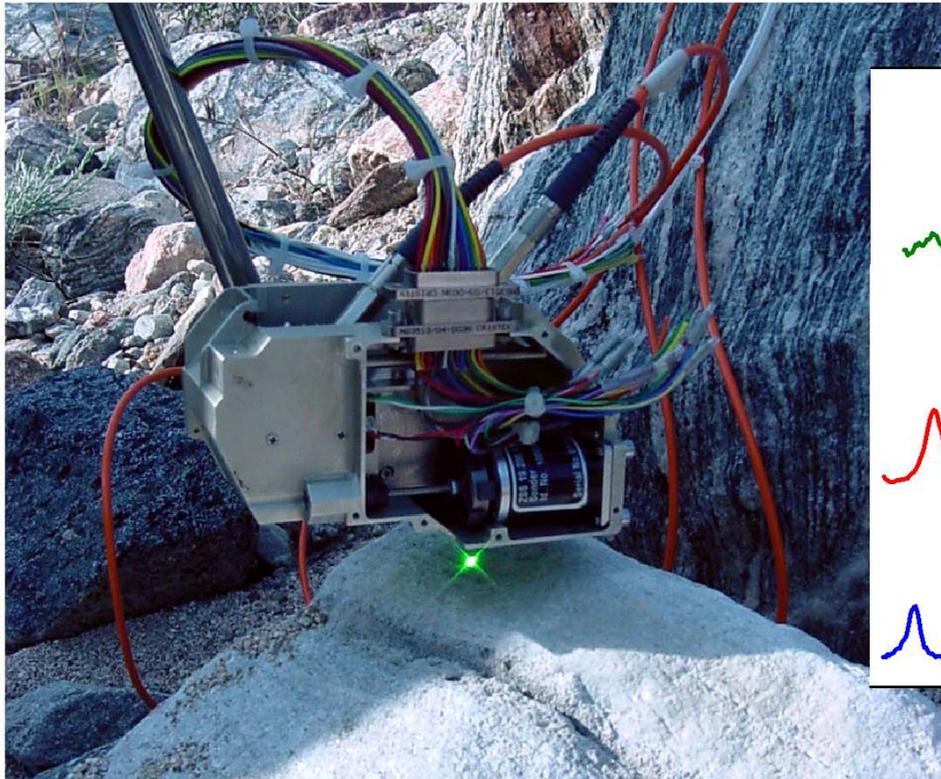
Raw Raman spectra of standard minerals at -24°C



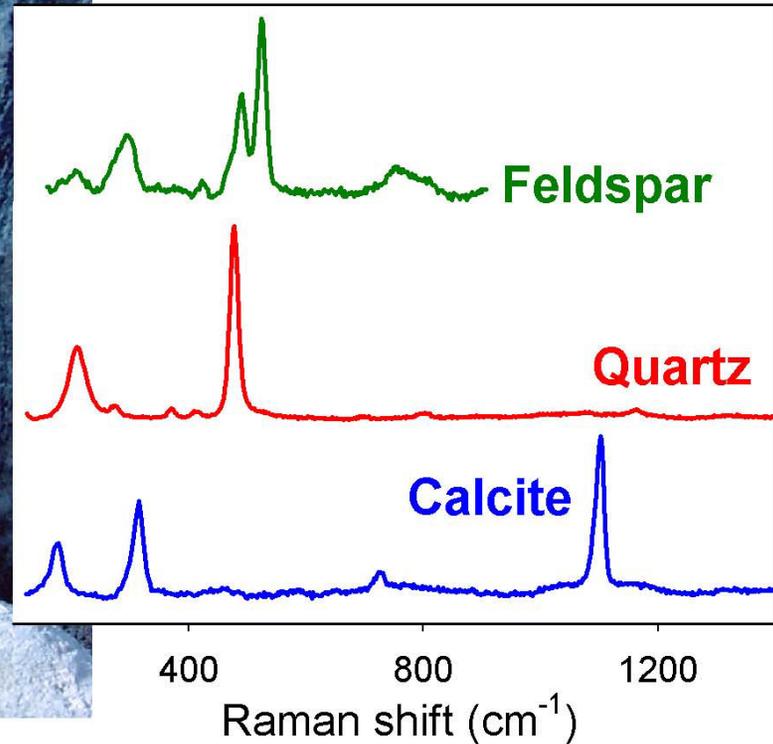
Raw Raman spectrum of ice core at -24°C



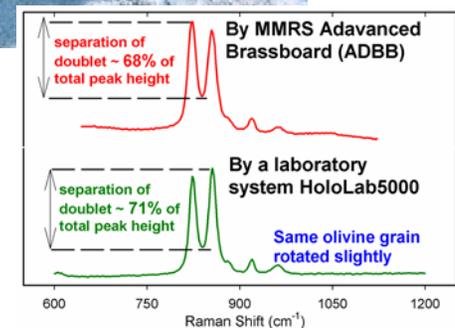
Mars Microbeam Raman Spectrometer



MMRS field test spectra



- Keeping the Instrument Team together
- Sustained Funding
 - Including science
 - To bridge gaps & retire risk
- Realistic field tests and demonstrations
 - Realistic environments
 - Cost of maintaining BB instrument
- Finding and Responding to Flight Opportunities
 - Realism in cost estimates (with experience from Athena)



During MSL Evaluation & Selection:

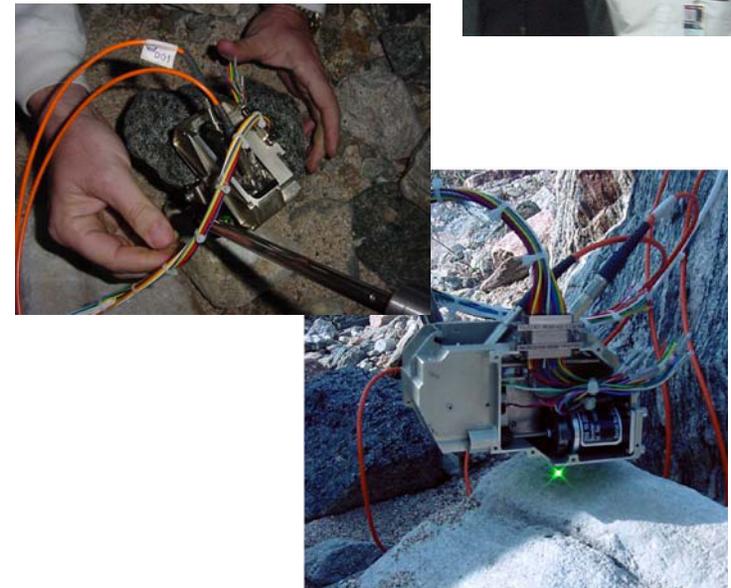
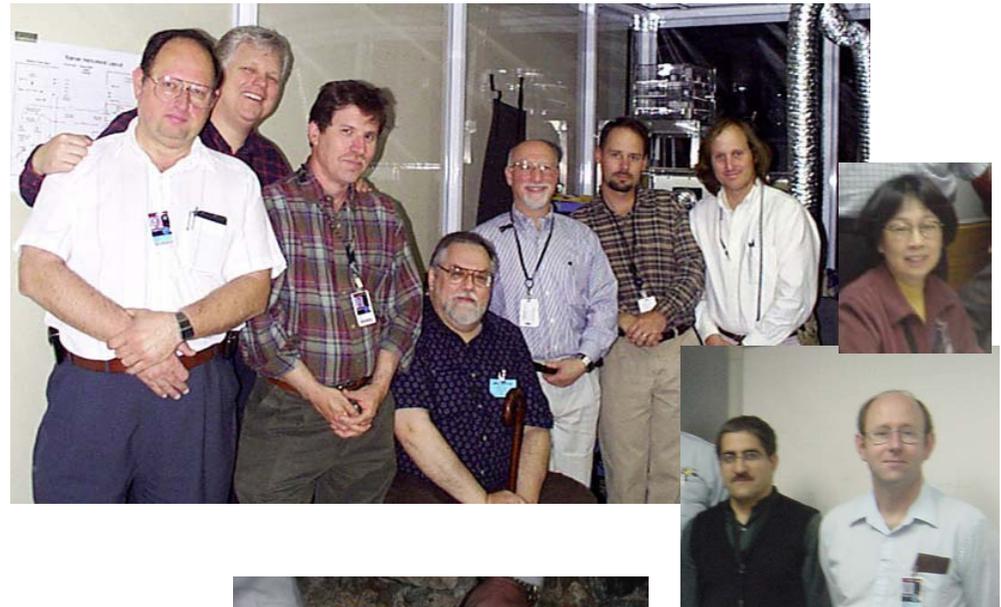
1. MMRS achieved the highest category ranking: “1”
2. Summary scores of “High”
 - a. Science merit – *accepted by Sci. community*
 - b. Science Implementation
 - c. TMC – *Technical maturity accepted by mission engineer and managers*
3. Overall risk rating of “low”.

Non-selection for MSL payload - mainly related to **budget limitations** and **payload configuration issues**.

MMRS is ready for any near term mission to Mars & Moon.

- **A strong instrument team**
 - PI, Co-I's at Wash U.
 - Engineering Team led by JPL
 - Strong extended Science Team
 - Perseverance and belief in the product
- **A successful design**
 - Design to science-based requirements
 - Top priority = highest possible signal strength
 - High spectral resolution & wide spectral range
 - Microbeam and linear scanning
 - Deployment strategies (arm-based, in-situ, Haskin point-count traverse method)
 - Flexibility: multiple probes w/ a single spectrometer

- **Importance of a coherent development team!**
- **Integration & accommodation heritage - - experience gained in prep for Athena '01/'03.**
- **Think outside box to maintain funding...**
- **Importance of field and environmental testing and demonstration.**
- **Need to recognize that instruments must keep up with technology. What we put on the shelf after MIDP might be obsolete by the next opportunity.**

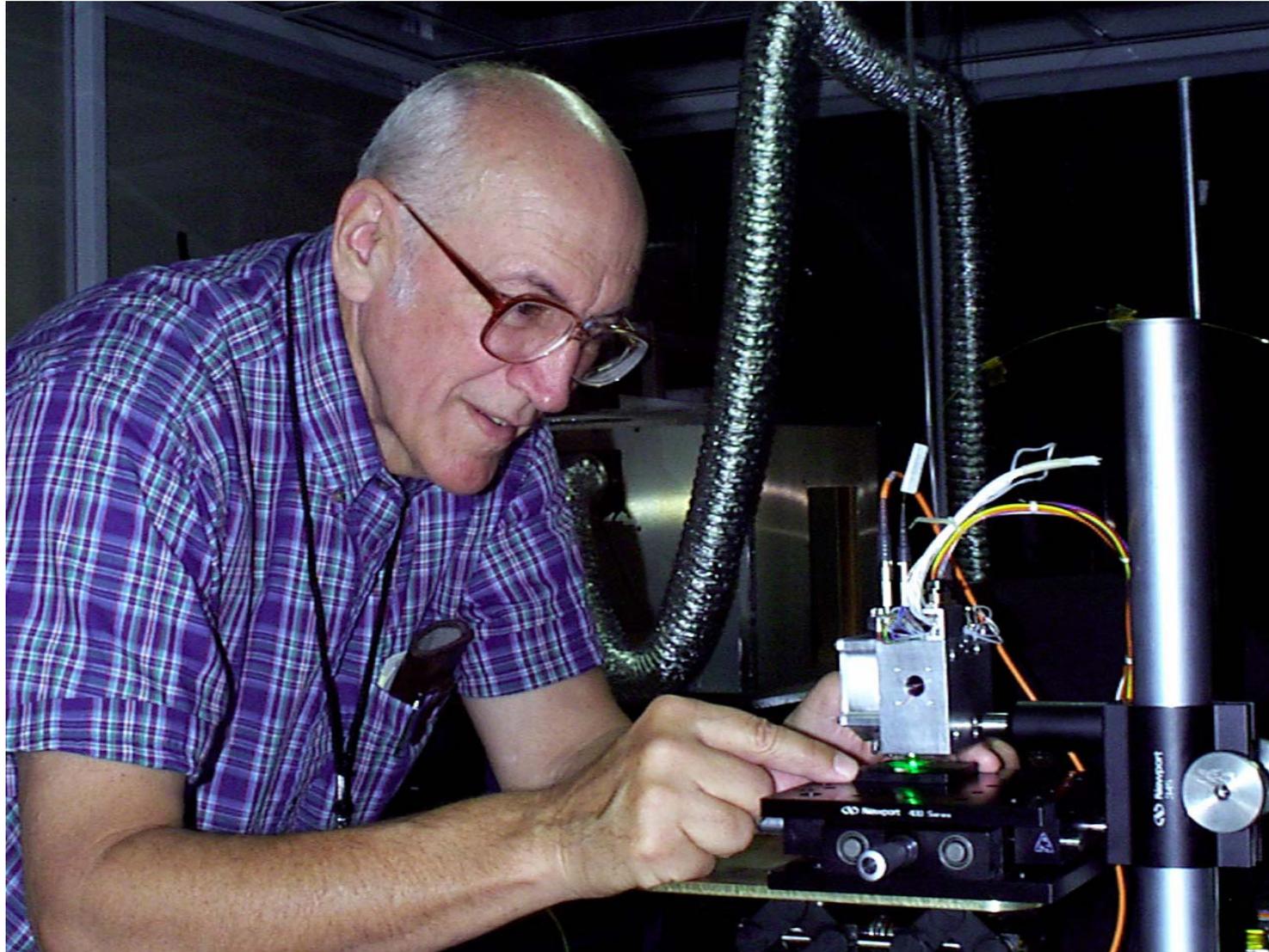




Dedication: Larry A. Haskin, PI – MMRS



Mars Microbeam Raman Spectrometer



1934-
2005